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ON-SITE INCINERATION OF CONTAMINATED SOIL:

A STUDY INTO
U. S. NAVY APPLICATIONS

Thesis
R27842

Thomas C. Reeves

M. S. Special Problem

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Environmental
Engineering in Civil Engineering in the Graduate
College of the University of Illinois at Urbana-Champaign.

Graduate Advisor: Dr. John T. Pfeffer

August 1991

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Executive Summary

The on-site incineration of hazardous wastes is a treatment option available for almost every contaminated site involving organic wastes. Rotary kilns are capable of destroying solid, liquid, and gaseous wastes with destruction efficiencies exceeding 99.99%. With current monitoring technologies and fail-safe equipment, the accidental emission of harmful compounds can be virtually eliminated.

With an environmental restoration program already activated, the Navy could benefit from the use of incineration technologies for the clean-up of many of its contaminated sites. On-site incineration can provide the Navy with the benefit of rapid destruction of the organic waste compounds and can reduce the risks involved in transporting the wastes to treatment centers. The destruction of the wastes eliminates the future liabilities that can exist when wastes are placed in landfills or passed along to private treatment companies.

Service contracts for the incineration of contaminated soils can follow the same guidelines as other cost-plus award fee contracts currently used by the Navy. The contracts must include terms which recognize the unique factors involved in hazardous waste incineration such as RCRA permits, test burns, and air monitoring companies.

With public education about the benefits of incineration over other technologies, and the promotion of successful applications, the public can be convinced that incineration can be a safe and advantageous treatment method with the capability to return contaminated sites to their natural conditions.

T253544

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Introduction

By Executive Order 12088 dated October 13, 1978, President Carter ordered all Federal agencies, including the Department of Defense (DOD), to comply with applicable pollution control standards and to cooperate with the Environmental Protection Agency and other state and local environmental agencies. In addition, the President established a limit to exemptions from pollution standards for Federal agencies, with said exemptions granted only through statutory determination of national security interests or other paramount interests of the United States. The limit to exemptions was a clear signal that the Federal government was going to have to learn to conduct its business in an environmentally-sound manner.

This Presidential Order placed on the U. S. Navy the same responsibility for environmental awareness that was placed onto other Federal, state, and private entities by the pollution control legislation. From the Clean Air and the Solid Waste Disposal Acts to the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensations, and Liabilities Act, the Navy has Executive and Congressional mandates to ensure that its operations are conducted with environmentally-responsible methods and to remediate past environmental mismanagement.

The environmental health of Navy installations reflects the environmental conditions in the rest of the United States. Across the nation, leaking fuel storage tanks have saturated soils and contaminated groundwaters, PCBs from old transformers have contaminated soils and storage structures, and metal and organic compounds have migrated from inadequate storage and disposal sites. With the possible exception of ordnance contamination of soil and groundwater, nearly all incidents of contamination at Navy installations can be expected to exist in local government or private situations.

This widespread similarity between the private sector and the Navy will allow the Navy to adopt proven technologies for cleanup operations.

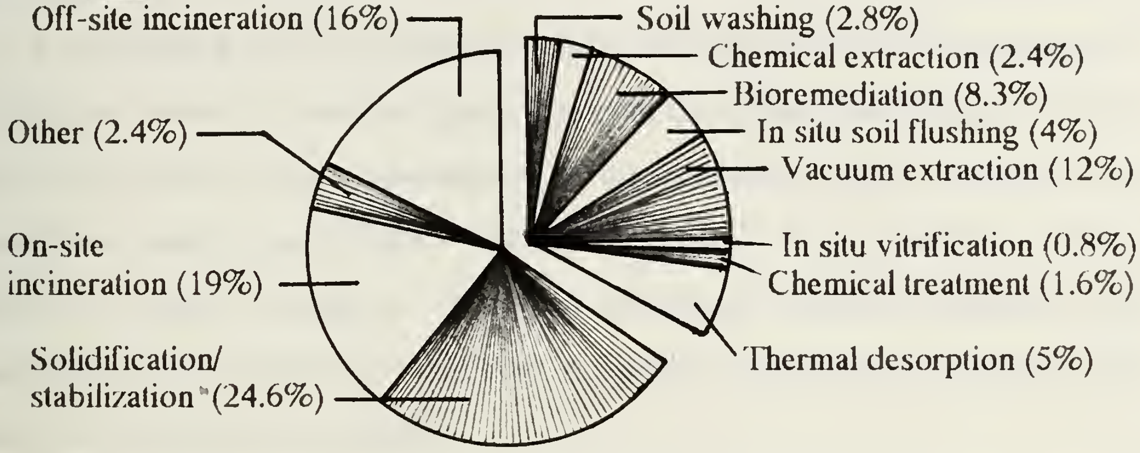
As increased funding is provided for the remediation of contaminated sites, new technologies will emerge to compliment the existing list of proven technologies. Any contaminated site will have characteristics that will allow the consideration of several different treatment techniques. The treatment technique will be chosen with regard to costs, risks, and desired treatment levels. The EPA has categorized treatment technologies by identifying them as established or innovative. Of the Superfund site cleanup plans issued between 1982 and 1989, 61% of the specified techniques have been the established technologies of incineration and solidification/stabilization. Thirty-seven percent of the specified techniques have been innovative technologies, such as bioremediation, vacuum extraction, and soil washing.[1] Figure 1 shows this data.

The fact that incineration is listed as an established technology and that it has been chosen by so many Superfund cleanup plans is a strong argument in support of incineration. The function of an incinerator is to destroy waste in a safe, environmentally-acceptable and cost effective manner.[2] Today, perhaps the biggest challenge involving the incineration of wastes is the public opposition. Environmental and local civic groups often challenge the safety and environmental impact of incineration. Even with the challenges, incineration is expected to continue as a major technology for waste destruction.[3]

This paper will explain the key issues involving incineration and detail the advantages of incineration over other treatment options. Further, it will investigate the use of mobile incinerators on Navy remediation projects and discuss the key issues involved in the implementation of incinerators into the Navy contracting methods.

Superfund Site Cleanup Technologies[1]

Established technologies (63%) Innovative technologies (37%)



Shows frequency of selection and use in Superfund records of decision between 1982 and 1989

Source: U. S. Environmental Protection Agency

Figure 1

An Argument for Incineration

Combustion

Combustion is the high temperature, rapid oxidation of carbon and hydrogen. It is a chemical reaction in which oxygen reacts with the carbon and hydrogen to form carbon dioxide and water. Incineration is the controlled use of combustion to accomplish a specific goal, which is usually the destruction of a waste for volume reduction or energy generation. While the differences between combustion and incineration are not important, in this text incineration will be used to describe the thermal destruction of waste material.

The incineration of wastes was used in the United States as early as 1885.[4] Even as recently as 1950, the use of incineration as a waste disposal method did not include a concern for the environment. Early incinerators were constructed and operated without concern for products of incomplete combustion (PICs), particulate matter, or other pollutants. Today, with the implementation of the Clean Air Act of 1970 and its subsequent amendments, incineration has evolved into an advantageous and safe disposal option.

Modern incineration technologies are extremely advanced over the technologies in use only thirty years ago. Air pollution control devices have been studied and developed that can reduce harmful gases and particulate matter from the exhausts of incinerators. But the public does not have the impression of incinerators as modern and safe reactors. As with landfills, the public maintains the vision of incinerators as sources of pollution. The public often perceives landfills as they have been in the past: un-engineered, leaking holes that stink and attract pests. The public also perceives incinerators as old, inefficient engines that emit black, noxious clouds of pollution that will eventually come to earth with the rain. Photographs of smog in Los Angeles and

other large cities lend support to the public who have no faith in the ability of engineers to provide clean air.

Given the past engineering practices concerning incineration, the fears of the public are not unfounded. But the public needs to be shown that modern incinerators can provide safe, environmentally-sound alternatives to other disposal methods. Actually, the public can honestly be told that incineration is a safer method of waste disposal than many other alternatives and that incineration should often be the first choice. As will be discussed later in this paper, a good incineration plan must include an aggressive public information program with public involvement in the early stages of the project planning.

To recommend incineration as a treatment option, the critical characteristics of combustion and incineration such as temperature, residence time, and PICs, must be understood. The efficient control of these characteristics is what makes incineration the best available technology (BAT) for many contaminated sites. A discussion of many of the critical characteristics and of the part they play in incineration is presented below.

Temperature

Temperature is probably the most significant factor in the destruction of hazardous waste.[5] In early refuse incinerators, it was believed that a temperature of 1200° F was sufficient to minimize the odors during incineration and was therefore the target temperature.[6] However, at this temperature, a multitude of un-combusted compounds were being emitted into the atmosphere through the flue gas. As concern for air quality and analytical techniques improved, it became clear that the 1200° F flame temperature would not be sufficient to meet the new emission standards. Many compounds in waste streams will not even ignite at 1200° F, much less cleanly combust to carbon dioxide. Cyanogen, for example, has an ignition temperature of 1562° F.

Residence Time

The residence time in an incinerator is defined as the actual time a waste constituent or its by-products remain within the combustion chambers. This time is critical and is influenced by the geometry of the chambers and the combustion air flow. Increased combustion air flow can allow for increased waste feed, but it will also decrease the residence time of the compounds within the chambers. The required residence time of a gas in the chamber is often linked to the temperature in the chambers. For instance, EPA requires the following combustion criteria for the incineration of liquid PCBs[5]:

1) The liquids introduced must be maintained for a 2-second dwell time at 1200 ± 100 degrees Centigrade and 3 percent excess oxygen in the stack gas.

or

2) Alternately, the liquids introduced must be maintained for a 1.5 -second dwell time at 1600 ± 100 degrees Centigrade and 2 percent excess oxygen in the stack gas.

Principal Organic Hazardous Constituent

The Principal Organic Hazardous Constituent (POHC) is a specific compound in the waste stream that is selected for monitoring during the trial burn of an incinerator.[4] The flue gas of the incinerator is monitored for the POHC and its by-products to determine the Destruction and Removal Efficiency (DRE) of the incinerator. The POHC of a trial burn must be equally or more difficult to burn than the other compounds in the waste stream. More than one compound may be identified as a POHC such as the most abundant compound in the waste and the most toxic. Additionally, when any waste stream includes chlorinated aromatics, dioxins and furans are sure to be among the POHCs.

Combustion By-products

The chemical reactions that are present during complete combustion create carbon dioxide and water from carbon, oxygen, and hydrogen. These compounds are the end products and do not reflect the intermediate reactions or intermediate compounds present during the combustion process. The combustion by-products resulting from complete combustion will be a direct result of the elemental analysis of the waste stream and of the combustion air. Table 1 shows some of the standard combustion reactions that can be expected from a properly-operating combustion chamber.

Standard Combustion Reactions

$$C + O_2 === CO_2$$

$$2\,H_2 + O_2 === 2\,H_2O$$

$$H^+ + Cl^- === HCl$$

$$N + O_2 === NO_2$$

$$S + O_2 === SO_2$$

Table 1

While none of these standard combustion products is considered desirable, they are typical products of combustion in many industrial combustors and power-generation boilers and their emission does not directly create adverse health effects (unlike dioxins and furans). Extensive research and field application have been conducted into equipment to remove hydrochloric acid and sulfur dioxide from flue gases using, for example, wet scrubbers and limestone adsorption towers, respectively. Modified high efficiency burners are being developed to limit the nitrogen dioxide formed during combustion. Since methods have been developed to limit the worst of the combustion by-products, attention is focused at preventing the formation and escape of intermediate products (PICs).

Mixing

The mixing of the combustion air with the waste compounds is critical to ensure complete combustion. A well-mixed reactor will have well-developed flame zones that will subject all of the waste compounds to the high temperatures. Poor mixing can result in cool zones within the reactors and thereby allow non- or partially-combusted compounds to leave the reactors.

Products of Incomplete Combustion

PICs are formed in the initial combustion chambers of incinerators and are actually gases, organic compounds, or metallic organics that were not completely disassembled during the combustion reactions.[4] They can be caused by insufficient temperature, insufficient residence time, insufficient oxygen, or incomplete mixing. The monitoring of the PICs and the ability to destroy them and the POHCs are at the foundation of every incineration permit. It is the escape of PICs that constitutes the hazards of incineration.

Incinerators

An incinerator is basically a combination of a furnace and a chemical process system with the primary purpose of waste destruction and volume reduction.[7] An incinerator can be operated with an energy recovery process, but the recovered energy is a side benefit and is not involved in the primary purpose. Specifically, an incinerator is used to achieve thermal destruction of a waste. Many types of thermal destruction devices exist today, some with specialized waste requirements. This paper will focus on the rotary kiln incinerator, a widely used incinerator because of its versatility. A rotary kiln is capable of incinerating liquids, solids, and gases simultaneously.

A rotary kiln incinerator consists of a large rotating, refractory-lined drum with the input end raised (Figure 2). The rotational movement of the drum around the horizontal axis moves the solid waste towards the output end while mixing it. Good mixing in the drum is necessary to ensure that all of the waste is exposed to the high temperatures. The rotation speed of the drum determines the solids detention time, which can be hours[8]. Within this drum, the waste is subjected to a temperature around 1400 - 2000° F.[7] The volatile components of the waste are volatilized and leave the drum with the gas stream. The non-volatile organic components are combusted within the drum, with the inorganic ash leaving the system at the end of the drum. If the waste does not contain enough organic matter to sustain the combustion at the proper temperatures, an auxiliary fuel can be used.

Subsequent to the rotary kiln is a secondary combustion chamber with the primary responsibility to completely combust the volatile waste components remaining and the PICs formed in the kiln. The afterburner in the secondary combustion chamber will usually burn auxiliary fuel to ensure constant temperatures around 2400°F. Since this chamber is the last chance for combusting waste compounds and PICs, its proper operation is critical. Liquid wastes will normally be sprayed directly into the secondary chamber with water-cooled wands.

Typical Rotary Kiln Incineration Unit[4]

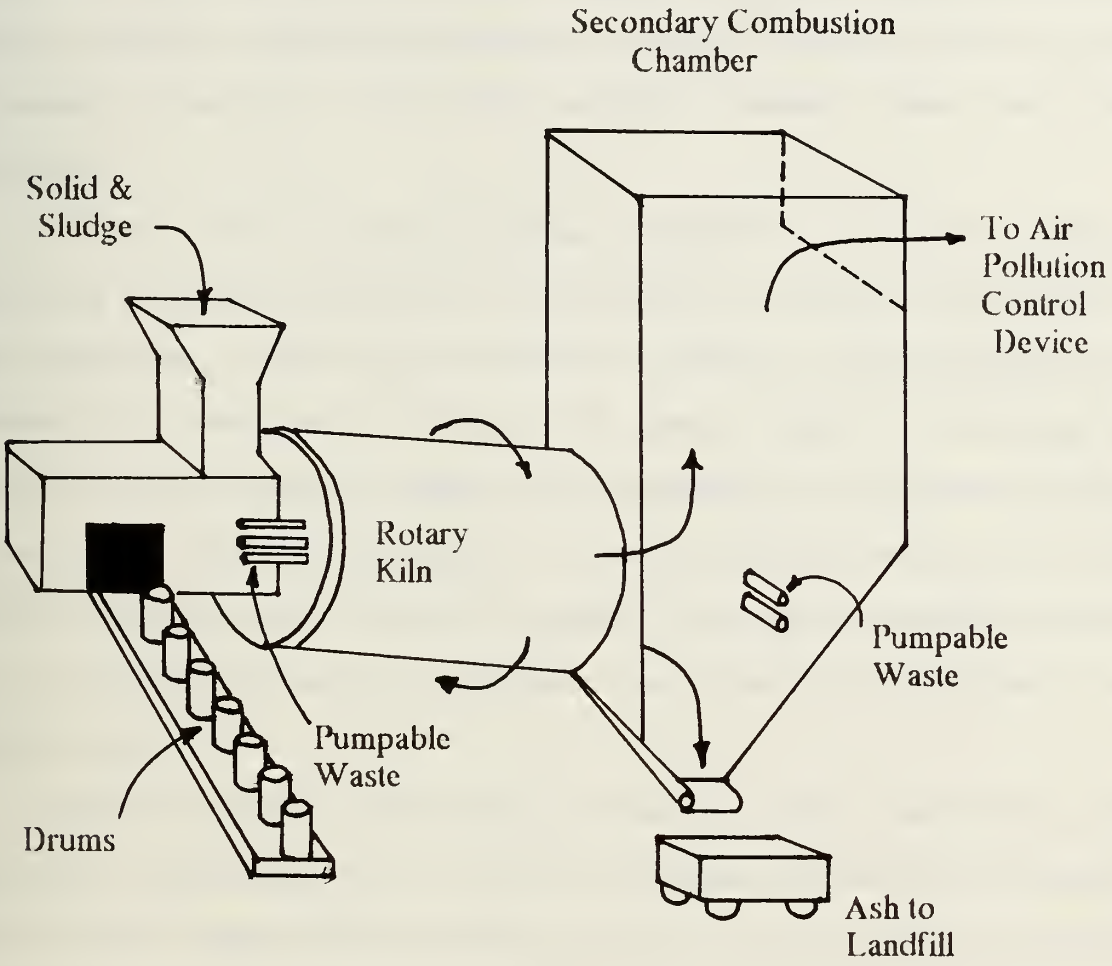


Figure 2

To reduce maintenance costs, the best operating conditions involve a continuous incineration schedule: twenty-four hours a day, seven days a week.[7] All rotary kilns have pollution control equipment to ensure adherence to the particulate and acid gas emission standards. Additionally, incinerators must have "fail-safe" systems to allow for automatic waste feed cutoff when operating parameters violate the permit boundaries.[11]

To improve the economic and political acceptability of incinerators, auxiliary fuel burners are being developed which would reduce the nitrogen oxides produced during combustion. Research has shown that the utilization of pure oxygen for the combustion gas instead of air will reduce the nitrogen oxides by eliminating the nitrogen from the air, will save auxiliary fuel by eliminating the requirement of heating the nitrogen, and will reduce particulates in the flue gas by producing lower gas velocities within the primary combustion chambers.[12] Since dioxin molecules normally leave the incinerators attached to particulates, the reduction of particulates is an important result.

On-site incineration involves the use of mobile treatment units (MTUs) and transportable treatment units (TTUs). MTUs are incinerator systems that are mounted on a few trailers or skids and have relatively short start-up times, some as short as one or two days.[13] They usually include their own support systems, such as generators and wastewater treatment systems, and are normally used for smaller cleanup projects of less than a year. TTUs are larger, semi-permanent incinerator systems that require ten to twenty trailers and start-up times of several months. They provide the advantage of larger capacity while forfeiting rapid set-up times and are used for larger cleanup operations that will last for more than a year.[13] The use of MTUs and TTUs will reduce the competition for the limited treatment capacity at fixed incinerators and thereby help reduce the possible shortfall in fixed facility capacity.[13]

On-site incinerators are currently being used or developed by the following companies[8]:

Existing:
EPA-Office of Research and Development
ENSCO Environmental Services, Franklin, TN
Winston Technology Inc., Lauderhill, FL
DETOXCO Inc., Walnut Creek, CA

Under development:
International Waste Energy Systems
John Zink Services, Inc.
Rollins Environmental Services
Trade Waste Incineration - A Division of Chemical Waste Management

When product recovery instead of product destruction is intended, as in the recovery of unused fuels that have leaked from an underground storage tank, other thermal treatments are available. The Low Temperature Thermal Treatment (LT^3) involves the use of elevated temperatures to drive volatile organic compounds (VOCs) from the solid medium. As shown in Figure 3, heat is applied to the soil by a hot oil process through heat exchangers with the advantage of separating the heating medium from the waste. Since heat is applied through the hot oil, the flue gas from the heating unit does not come into contact with the contaminants in the soil. Another advantage of the system is that, since volatilization not incineration is the goal, the soil matrix does not have to be heated to the extreme temperatures required during incineration. With operating temperatures around 400° F, the LT^3 system has the capability of returning the soil to its original condition.[14] It is important to point out that this system was developed with the goal of treating soils contaminated with VOCs. Because of the low operating temperature, this system is not applicable for wastes with dioxins or PCBs.

Process Schematic:
Low Temperature Thermal Treatment System[14]

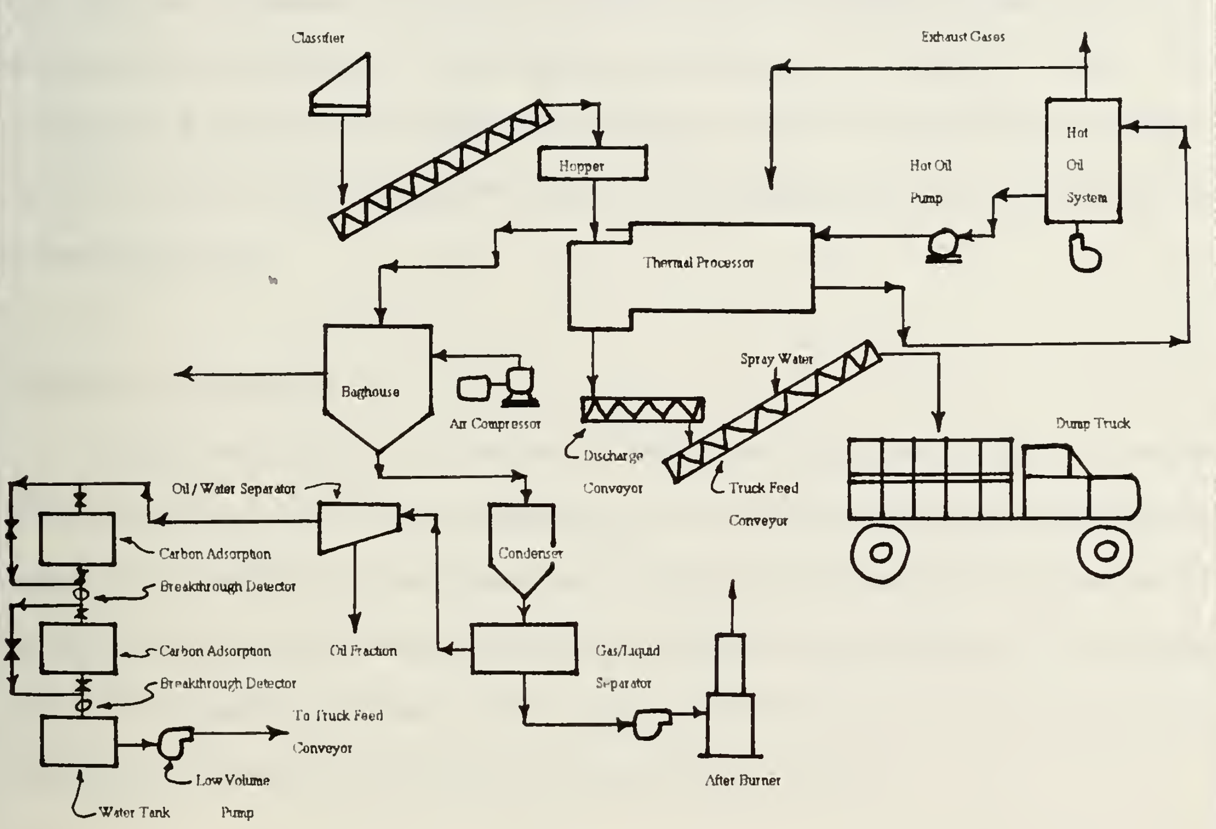


Figure 3

Alternate Treatment Technologies

Technologies other than incineration can be used to remediate a hazardous waste site. Depending upon the waste type, extent of contamination, and desired results, engineers have a variety of options available. The treatment results range from separating the contaminant from the environment to transforming the waste into less- or non-hazardous substances. Several of these technologies are explained below. The advantages of incineration over these technologies will be covered later in this paper. As can be seen in Table 2, however, none of the treatment methods is as versatile as thermal destruction.

Solidification/Stabilization

This technology involves the use of binding and neutralization agents to entrap liquid and sludge wastes within a solid matrix. Since the primary goal is minimizing the escape of the wastes, the matrix must have a high structural integrity.[15] Examples of binding agents include cements, lime, thermoplastic resins, and glass. The method chosen will depend significantly on the chemical characteristics of the waste. Upon stabilization, the solids are then placed into landfills for disposal.

Biological Treatment

Biological treatment of hazardous waste includes the identification and promotion of specialized bacteria that can utilize the wastes for metabolism. Co-metabolism, the transformation of a compound without apparent benefit (growth) of the cell, is also possible but must occur in the presence of a compound that can be used for growth. Common contacting methods include batch reactors, landfarms, lagoons, and leaching beds. In-situ treatment with biological cultures is also a possible contacting method.

Predicted Treatment Effectiveness For Contaminated Soil[16]

Treatability Group	Technology Bioremediation	 Immobilization	 Dechlorination	 Solvent Extraction	 Thermal Destruction
Non-Polar Halogenated Aromatics (W01)	◒	O[1]	◒[1]	◒	●
Halogenated PCBs Dioxins, Furans and Their Precursors (W02)	◒	O[1]	◒	◒	●
Halogenated Phenols, Cresols, Amines, Thiols, and Other Polar Aromatics (W03)	◒	O[1]	◒[1]	◒	●
Halogenated Aliphatic Compounds (W04)	●	X	◒[1]	◒	●
Halogenated Cyclic Aliphatics, Ethers, Esters, and Ketones (W05)	O[2]	O[2]	◒[2]	◒[2]	●
Nitrated Compounds (W06)	●	O[2]	O[3]	◒	●
Heterocyclics and Simple Non-Halogenated Aromatics (W07)	●	X	O[3]	●	●
Polynuclear Aromatics (W08)	●	O[1]	O[3]	◒	●
Other Polar Non-Halogenated Organic Compounds (W09)	●	O[1]	O[3]	◒	●
Non-Volatile Metals (W10)	X	●	O[3]	◒	O[3]
Volatile Metals (W11)	X	●	O[3]	◒	X

●	**Demonstrated effectiveness**
◒	**Potentially effective** (in certain situations)
O	No expected effectiveness (no expected interference to process)
X	Not recommended (potential adverse effects to environment or process)

1 Data were screened from consideration for regulatory purposes. These data suggest that this technology may be effective in certain situations

2 Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology may be effective in certain situations

3 The physical and/or chemical characteristics of the constituent of this readability group suggest that this technology would not be effective

Table 2

Chemical Treatment

Chemical treatment can include neutralization of acidic or basic wastes, precipitation of hazardous compounds utilizing oxidation and reduction reactions, coagulation and flocculation, and dechlorination. Often, chemical treatment processes convert toxic and hazardous wastes into non-toxic or less-hazardous compounds that still require further treatment or recovery.

Physical Treatment

Physical treatment methods can include membrane separation processes, air stripping, adsorption, distillation, and other physical processes that are aimed at removing the contaminants from the environmental carrier (soil or water) or at significantly reducing the volume of the waste stream by concentrating the waste.

All of the available treatment techniques were not described in the information above. The descriptions included did, however, provide general information about the alternatives to incineration and will allow a discussion of the advantages of incineration when compared to the alternative methods.

Advantages and disadvantages of incineration

The possible release of POHCs and PICs is the biggest disadvantage of incineration and is the most prevalent challenge to hazardous waste incineration permits. Specifically, the release of dioxins and furans is a major concern of civic and health groups opposed to incineration. Several arguments can be made against the carbon dioxide and nitrogen dioxide that are produced by incinerators. However, incinerators are such small contributors to the total mass of each of these contaminants emitted each year that they produce no significant amount. Power generation facilities and vehicle exhausts contribute much more of the "standard air pollutants" than incinerators so that incinerators can be ignored as insignificant contributors in this instance.

Presently, the cost of incineration is often inhibitory. Trial burns for incinerators can cost as much as $200,000, and the cost per ton of a landfillable waste can be as high as $142 for incineration versus $50.46 for landfilling (1981 dollars).[17] As regulatory requirements develop against landfilling, the economic justification for incineration can be expected to improve. Solidification also has an economic advantage over incineration, with prices of incineration of solids and sludges ranging from $5 to $8 per gallon compared to $3 per gallon of solidification processes.[18] Since the EPA has required incineration only for solvents, dioxins, and halogenated organics, the generator's preference prevails for the treatment of other organic wastes and therefore economics plays an important role in how hazardous waste treatment decisions are made.[18]

A primary advantage of incineration over other treatment options is that incineration can provide the complete destruction of the hazardous organic constituents in every waste stream. This is significantly different from many of the alternate treatment processes discussed earlier, most of which provide the separation of the waste from the environment. The Superfund program's mandate is to select cleanup

remedies that permanently decrease the toxicity, mobility, and volume of hazardous wastes.[16] This mandate is the perfect description of incineration results. Precipitation, coagulation, extraction, and adsorption all produce a concentrated waste product, usually with an additional chemical compound or carrier added to the waste stream. Incineration destroys the hazardous organic compounds and leaves only inorganic ash and hydrochloric acid (which is easily neutralized) as waste products.

Incineration is a rapid treatment method, with typical load rates of mobile incinerators of 25 tons of contaminated soil per day.[13] Compared to biological treatment of soil, which may take years or even decades for detoxification, incineration provides the important benefit of a rapid completion to the treatment project. Depending upon the operational schedule and the scope of the contaminants, an incineration project could include an on-site period from several months to several years. At the Cornhusker Army Ammunition Plant near Grand Island, Nebraska, forty-thousand tons of explosive-contaminated soil were incinerated between October 1987 and July 1988, a time which included a non-incineration period from mid-October 1987 to February 1988.[19] Other treatment methods may include rapid completion of chemical or physical waste treatment in either continuous or batch process, but few can offer the rapid destruction of the waste.

Mobile incinerators offer the advantage of on-site destruction of the waste. A large cost in most off-site remediation schemes can be expected to be the transportation costs associated with transferring the waste to the treatment site and the ultimate disposal site. On-site incineration systems could operate without any interstate or highway transportation requirements, especially if the ash from the incinerator does not include any heavy metals or other contaminants or can be retained on-site. Also, with the requirements for hazardous waste manifesting and transporting, the transportation of hazardous wastes across large distances should be avoided if at all possible.

The versatility of incinerators is surely responsible for the growth of incineration as a treatment technology. Incineration as a technology is applicable to liquids, solids, sludges, and gases. Many incinerators can handle wastes in more than one physical state. Most rotary kilns, for example, can treat liquid and gas wastes using spray nozzles while at the same time treating solid wastes in soil or other matrices. Some slagging incinerators can process wastes in drums; the drum of waste is fed into the incinerator, the waste is incinerated, and the steel drum exits as a molten slag. As a comparison, the type of solidification technique used is highly dependent upon the type of waste. Biological treatment of wastes may often require substantial dilution of the waste to a biodegradable concentration. A waste stream may often require treatment before exposure to a biological culture to ensure no other toxic compounds are included along with the waste that is to be processed. The chemical treatment of a waste stream may only affect one compound of the stream, requiring further treatment or disposal of a still-hazardous waste. With incineration, however, the waste may be loaded in practically any form, concentration, or combination, and, with the exception of metals and other inorganics, the waste will be destroyed.

Regulatory Control

The Resource Recovery Act of 1970, a federal law intent on initializing the overhaul of the nation's solid waste disposal practices, was also the first federal law to recognize that there was a serious problem in the way toxic and hazardous waste were managed.[6]

The 1976 Resource Conservation and Recovery Act (RCRA) was the federal law responsible for defining the differences between solid and hazardous wastes and for establishing the regulatory mood for future environmental legislation. The impact of RCRA on the practices of American industry is enormous, and it plays a lead role in the remediation programs discussed in this paper. It established the accountability of generators, transporters, and disposers for the safety of their operations and for the proper disposal of the hazardous wastes.

The Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) broke new legislative ground by declaring that the federal government would take an aggressive role in the cleanup of the environment. The law was designed to pass the cost of remediation programs back to the responsible private parties. It created a Superfund of money for orphaned sites that is financed by taxes on the chemical manufacturing industry.[6] Equally important, however, are two other policies that come from the law: first, the Superfund will allow remedial action for contaminated sites even without a reimbursement agreement with the responsible parties, and second, it established the legal responsibility of proper waste disposal onto the waste generators. Even if a waste generator properly passes the waste onto a permitted landfill or waste disposal company, the generator is still liable for the proper disposal and the future behavior of the waste.

The impact on the remediation of contaminated sites and on incineration programs by RCRA, CERCLA, and the Superfund Amendments and Reauthorization Act (SARA), which provided money for the Superfund, is substantial. Hazardous waste incinerators are permitted under RCRA Part B guidelines.[20] RCRA has also set the guidelines for the cradle-to-grave manifest system, which regulates the transportation of the wastes.

The EPA has established Destruction and Removal Efficiencies (DRE) for compounds in incinerated wastes to prevent the escape of these compounds through the stack. For PCBs, EPA has mandated a DRE greater than 99.9999%[5]. RCRA has established performance standards for the incineration of hazardous wastes[5]:

1) A DRE of 99.99% for each POHC designated.
2) A maximum HCl emission in the flue gas of 1.8 Kg/hr or 1% of the HCl that existed before the pollution control equipment, whichever is less.
3) Maximum particulate matter emission of 180 mg per dscm, corrected to 7% oxygen.

Trends in Regulations

To accompany the landfill ban on contaminated soil and debris, EPA must chose a Best Demonstrated Available Treatment (BDAT) upon which to base the treatment standards. In EPA's initial review of soil treatment data, incineration was proven to be highly effective. If incineration is to be chosen as the BDAT for soil and debris, its position in the remediation market would surely be strengthened.[16]

However, the path for incineration has not been totally cleared. RCRA Part B permits can take as long as two or three years to be issued. While Section 121 of SARA releases Superfund sites from federal, state, and local permits, non-Superfund sites are required to obtain state and local permits.[16] Three-year permitting processes will surely kill the idea of using mobile incinerators for small cleanups. The confidence that is shown in incineration at Superfund sites is ignored at non-Superfund sites.

A proposed EPA permit rule would also require the use of mobile incinerators to be linked with RCRA corrective actions, which would require total site cleanup anywhere a mobile incinerator is used.[16] This would definitely discourage the use of mobile incinerators to accomplish the small, short term housekeeping cleanups where the incinerator application could excel.

Environmental Status at Naval Installations

CERCLA and SARA established the Superfund and provided cleanup and emergency response funds for hazardous substances released into the environment at non-Department of Defense installations. Since DOD is excluded from utilizing Superfund money[21], Congress created the Defense Environmental Restoration Program (DERP) to fund the environmental cleanup on DOD properties. From the DERP guidelines, the Navy has created the NACIP (Navy Assessment and Control of Installation Pollutants) Program.

Patterned after the Superfund project development process, the NACIP Program includes the following phases:

NACIP	Superfund
Phase I: Initial Assessment Study	Preliminary Assessment Site Inspection
Phase II: Confirmation Study	Remedial Investigation/Feasibility Study
Phase III: Implementation of Corrective Measures	Record of Decision Remedial Design Remedial Action

While the time involved in the remediation program will differ for each site, it can be seen from Figure 4 that the time span could stretch from four to eight years. This extended time frame is needed to ensure that complete investigative efforts are undertaken and to allow for Federal and local agencies to permit the remediation plan. As experience is gained with the remedial efforts and confidence is gained with the technologies utilized, the time span from beginning to end should decrease noticeably.

Installation Restoration Timeline[22]

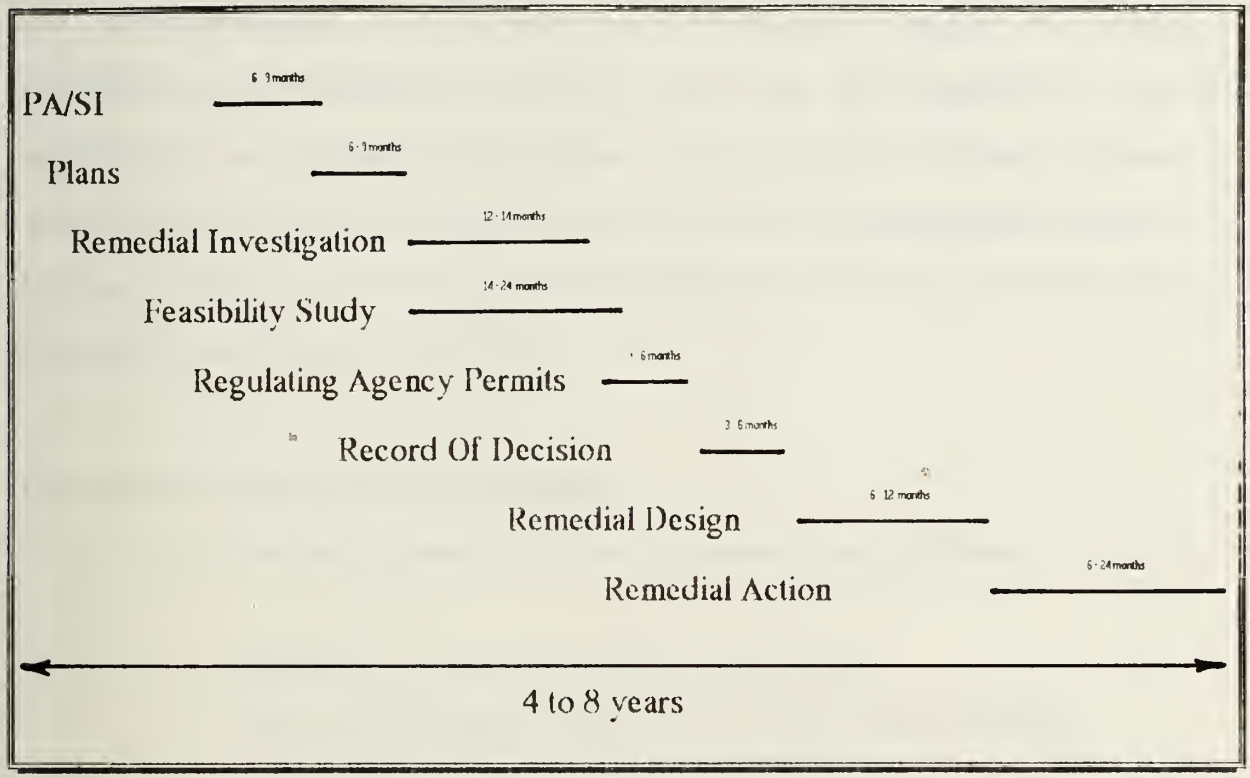


Figure 4

In Superfund projects, the Record of Decision identifies the potentially responsible parties and the basis for cost recovery for the Government-funded cleanup action. Since the generator of the contamination at Navy sites will not usually be questioned, the identification of responsible parties for cost recovery is not expected to be a normal part of the program. Money will be dedicated from the DERP funds for each NACIP site. It is conceivable that some non-Navy or non-DOD parties could be involved in some of the contaminated sites and could be accountable for a portion of the cleanup costs, but this scenario can be expected to be a rare exception to the normal implementation of the NACIP Program.

By 1990, the Navy had identified over 2000 contaminated sites at 184 Navy and Marine Corps installations.[23]. Using the EPA's model for estimating remediation costs, one estimate projected a cost of more than $2.3 billion to complete the installation restoration at Navy facilities.[23] The Navy's Fiscal Year 1991 requirement for NACIP expenditures was identified at $260 million. Although most of the funds obligated to date have been used for site investigation and confirmation, some remedial actions have been implemented. By 1990, design and construction of cleanups were underway or complete at more than 100 Navy sites.[24]

Contaminated Sites at Naval Installations

The top five wastes generated by Navy operations are as follows[21]:

a. Petroleum, Oil, Lubricants (POL), and solvents
b. Other (nonrecurring wastes not easily fit into other categories)
c. Inert (rubble, usually construction debris)
d. Ordnance
e. PCB

While identifying the waste types does describe one aspect of the Navy's problems, a more informative description can be found in the listing of the five major contaminant categories/site problems found at Navy installations:[21]

a. Organic substance contamination of groundwater and soil
b. Combined wastes in landfills resulting in groundwater contamination
c. PCBs and pesticides contamination of groundwater and soil
d. Ordnance-related compounds contaminating groundwater and soil
e. Heavy metal contamination of groundwater and soil/sediment

Because of the various mediums that can contain the same waste, it is advantageous to identify the common industrial wastes and assign each to one of the

major contaminant categories. For example, knowing that heavy metals are the primary hazardous constituent of blasting grit provides information concerning the hazards and possible treatment options involved with blasting grit. Table 3 reflects the types of wastes generated at Navy facilities and assigns each to a contaminant category and thereby to an available treatment option.

By grouping individual wastes into contaminant categories, wastes can also be grouped into treatment technologies. Table 4 identifies available technologies for each of the five waste categories. The information provided in Table 4 constitutes the top technologies in each category and does not reflect all of the available treatment options.

To further describe the environmental condition at Naval installations, all suspected contaminated sites are classified as one of thirteen possible site categories. Table 5 lists these categories.

Organization of Naval installations

The Naval Facilities Engineering Command (NAVFAC) is the engineering organization responsible for planning, procuring, and maintaining all facilities for the Navy. Comprised of Naval officers and civilian employees, NAVFAC's presence extends to every building, utility, infrastructure, and property owned or utilized by the Navy in support of fleet operations.

NAVFAC maintains seven Engineering Field Divisions (EFDs) which control the Naval facilities in all parts of the world. At an EFD, engineering, contracting, and planning personnel are positioned to provide technical assistance to the individual activities (bases) within a designated geographic region. It is through the EFDs that NAVFAC promulgates policies for procuring, maintaining, and planning the future of the facilities. The EFDs also provide expert technical advice and services for the activities.

Waste Type/Contaminant Category Pairing[21]

Waste Type	Contaminant Category
Acid	Acid Waste
Asbestos	Asbestos
Ash	Heavy Metals
Base	Caustic Waste
Blasting Grit	Heavy Metals
Dredge Spoils	Organic Compounds / Heavy Metals
Electrolyte	Acid Waste / Heavy Metals
Gas Cylinders	Unknown
Hypochlorite	Toxic Inorganic Compounds
Industrial Liquid Waste	Organic Compounds / Heavy Metals
Industrial Sludge	Organic Compounds / Heavy Metals
Industrial Wastewater	Organic Compounds
Inert	Not included
Low-level Radioactive Waste	Not included
Ordnance Compounds	Ordnance
Other	Organic Compounds/Heavy Metals/Toxic Inorganic Compounds
Paint	Heavy Metals
PCB	PCBs and Pesticides
Pesticides	PCBs and Pesticides
Plating Waste	Acid Waste/Toxic Inorganic Compounds (cyanide)/Heavy Metals
Petroleum, Oil, Lubricants	Organic Compounds
POL Sludge	Organic Compounds
Propellant	Organic Compounds
Refuse with Hazardous Waste	Organic Compounds/Heavy Metals/PCBs and Pesticides
Refuse without Hazardous Wastes	Organic Compounds / Heavy Metals
Scrap Metals	Heavy Metals
Solvents	Organic Compounds
Unexploded Ordnance	Ordnance

Table 3

Remedial Measures Technology Alternatives[21]

Contaminant Category	Groundwater	Soil
Organic Compounds	Photochemical Oxidation Biological Treatment Freeze Crystallization	Incineration Soil stripping Molten Glass
Combined Wastes	Adsorption Biological Treatment Freeze Crystallization	
PCBs and Pesticides	Photochemical Oxidation Freeze Crystallization Biological Treatment	Incineration Chemical Dechlorination Molten Glass
Ordnance	Photochemical Oxidation Carbon-Augmented Bio Treatment Freeze Crystallization	Molten Glass
Heavy Metals	Chemical Treatment Adsorption Above-ground Bio Treatment	Inorganic Solidification Chemical Treatment Molten Glass

Table 4

Site Categories at Naval Installations[21]

Site Category	Definition
1) Above-ground tanks	Tanks, usually containing fuels, whose structures are not primarily in contact with soil.
2) Burn area	A location at which firefighting exercises have been conducted using flammable solvents to create training fires
3) Disposal area	A "backyard" area that has received waste but has not been designated to receive wastes.
4) Disposal Pit (lined)	A depression in the earth with an engineering liner intended to control the migration of contaminants.
5) Disposal Pit (unlined)	A depression in the earth used for the disposal of wastes.
6) Inert site	A site that has received rubble, such as construction debris.
7) Landfill	A location designed to receive wastes and actively operated for the intentional disposal of wastes
8) Ordnance site	A location used for the disposal of ordnance materials, primarily chemicals associated with explosives.
9) Spill area	A location at which a leak or one-time spill event occurred.
10) Storage Area	A location at which drums or other containers were used to store materials that subsequently leaked or spilled.
11) UST	A tank, usually containing fuels, whose structure is primarily in contact with soil.
12) Waterbody	Nontransient water, such as a lake, river, estuary, or ocean.
13) Other	Sites that were judged not to fit into another category, such as radiological waste disposal, sediments, and pipelines.

Table 5

NAVFAC provides each Naval activity with a public works officer (PWO) responsible to the Commanding Officer of the activity for maintaining the activity's facilities and for planning for the future mission of the activity. Although the PWO works for the activity's Commanding Officer, the public works organization is responsible to the Commander of NAVFAC for following the procedures and guidelines that NAVFAC has established for the proper execution of the activity's maintenance and construction budget.

The extent of the public works department at each activity is based on the size of the installation and the mission of the activity. Large installations will have large public works departments, employing maintenance craftsmen, engineers, fiscal experts, and contract specialists. In addition to typical building and utility maintenance, such departments could have responsibility for maintaining railroads, cranes, sanitary and hazardous waste treatment plants, industrial operations such as foundries and electroplating shops, and many other diverse operations required for the Navy's mission. Small bases may have public works departments consisting of only a few employees. Such bases will have arrangements in which maintenance services are purchased through contracts from other Navy activities or from private businesses.

Commanding Officers (COs) are responsible for all operations onboard their installations, including all operations which could produce environmental contamination or damage. Since most COs have a limited formal education in environmental engineering topics, they rely extensively on their public works officers for the administration of the installations environmental protection programs. The PWOs, through their function of maintaining the installation, are also responsible for identifying contaminated sites onboard the installation and coordinating remedial action.

Navy Contracting Methods

The Naval Facilities Engineering Command is responsible for procuring Navy facilities and services relating to construction. Facilities contracting must be in accordance with the Federal Acquisition Regulations (FAR). The FAR was commissioned by Congress to establish a set of laws which Federal agencies must use for contracting supplies and services. The Department of Defense established the Defense Acquisition Regulations (DAR) to augment the FAR and to provide guidance for DOD agencies. These two documents establish contracting laws and procedures meant to protect the rights of private businesses that conduct business with the Government while protecting the Government's rights under contractual agreements.

For construction contracts and services, the FAR establishes contracting procedures that cover all procurement actions from project design to contract completion. Critical contract clauses are provided by the FAR and are included in contracts verbatim. To implement the legislative requirements of the FAR, NAVFAC has published the Contracting Manual (NAVFAC P-68) that establishes policy and procedures for contracting officers to follow while procuring facilities and services.

The environmental remediation contracts that will be used to remediate Navy sites will have to obey all of the FAR and DAR contracting rules. While the end result of the remediation contracts will be different from the typical construction contract, the contract procedures and administration will not be beyond the scope and training of existing contracting offices.

Most of the contracts in use today by the Navy for construction and services are fixed price contracts, in which the lowest qualified bidder is selected for a finite design. Excluding modifications, the contractor is responsible for delivering the finished product at the bid price.

Indefinite quantity contracts are used when the scope of the project is known but the exact quantity of the item requiring service is unknown. Often a sub-surface condition is not completely understood until excavation. With soil incineration, a contractor could be told to expect at least 25,000 cubic yards of contaminated soil but to be ready to handle up to 50,000 cubic yards. The price of the contract would be dependent upon the exact volume incinerated.

Cost-plus contracts can be of several types and include provisions for contractors to be reimbursed for all costs and to be given an additional sum for profit. Incentives are often provided for contractors to keep costs down, sometimes taking overruns out of the contractor's profit margin. Cost-plus percent-of-costs contracts, under which the contractor's fee would increase with increased performance costs, are prohibited. Cost-plus award fee is common and will provide the contractor an increased award fee for superior performance and for cost savings.

Contracts issued by the Navy are usually subject to free and open bidding and are normally awarded to the lowest responsible and responsive bidder. Responsibility is defined as a contractor's ability to perform and responsiveness is the degree of adherence between the offer and the bid.

Often, the Navy finds reason to contract by negotiation. Due to complicated specifications or specialized requirements, the Navy can limit bidders to a contract by requiring prequalification of interested bidders. Before the initial bids are accepted, contractors must prove that they are qualified to perform the work in question and must provide examples of past work experience. After a selection board identifies potential contractors, those contractors submit bids for the contract. If the contract is to be negotiated, the contracting officer can contact the bidders to discuss items about their bid. These negotiations do not include auctioning of the contract to produce a lower price nor do they include the transfer of information from one bidder to another. They are solely a means to verify the technical and financial acceptability of a bid.

Current Environmental Contracts

Currently, the Navy is involved with a contracting program entitled Comprehensive, Long Term Environmental Action, Navy (CLEAN). A CLEAN contract is awarded to a contractor who can perform preliminary assessment, site inspections, remedial investigations, feasibility studies, and remedial designs. A CLEAN contractor is given a one-year contract, with nine one-year options, to handle environmental assessment work in a certain geographic area.[23]

Cleanup operations are contracted separately as fixed price, indefinite quantity, or cost-plus contracts. For remedial actions up to $1 million, local contracting officers will have the option to use newly-developed Remedial Action Contracts (RACs). Eight RACs are being developed to handle nationwide remediation, one for each of the following waste types:

1) Waste petroleum
2) Clean petroleum
3) Combined wastes (landfills)
4) Polychlorinated biphenyls
5) Ordnance
6) Acids/bases/metals (plating wastes)
7) Pesticides
8) Solvents and paints

Larger remediation programs are contracted by the EFD as individual contracts.

Key issues in soil incineration

A contaminated site can be a collection of contaminated mediums: hazardous compounds adhered to the soil, free compounds on the surface of the groundwater, soluble compounds dissolved in the groundwater, gaseous compounds volatilizing from the soil and groundwater, and liquid and solid compounds existing freely on the surface or confined in containers. A remediation program must include the operations

that can remove the hazardous compounds in each of these states and either destroy or contain the resultant product. While incineration is a technology that can destroy the waste from each of these mediums, a remediation program will include, in addition to an incinerator, any of the possible subsystems shown in Table 6.

Subsystems of an Incineration Program[2]

1) Waste excavation
2) Waste transportation
3) Liquid waste receiving and unloading
4) Solid waste receiving and unloading
5) Primary storage and handling of liquid wastes
6) Primary storage and handling of solid wastes
7) Drum disposal
8) Blending
9) Pretreatment
10) Blended and pretreated solid waste storage
11) Blended and pretreated liquid waste storage
12) Solid waste feeding
13) Liquid waste feeding
14) Incinerating
15) Energy recovery
16) Quenching
17) Particulate removal from the flue gas
18) Acid gas removal
19) Prime moving
20) Flue gas dispersal
21) Wastewater treatment
22) Liquid effluent disposal
23) Solidification
24) Solid residue disposal
25) Reagent preparation
26) Fugitive emission control
27) Scrubber liquid cooling

Supporting Subsystems

28) Rainwater collection
29) Infrastructure
30) Utilities
31) Control systems
32) Emergency response

Table 6

It can easily be seen that soil incineration does not involve parking an incinerator in the middle of a field, turning it on, and starting to burn soil. The subsystems shown in Table 6 are part of an overall incineration system and will be identified in the site assessment and remedial design processes. Figure 5 is a process flow diagram of the ENSCO Environmental Services mobile rotary kiln incineration system and demonstrates the interaction between the different systems.

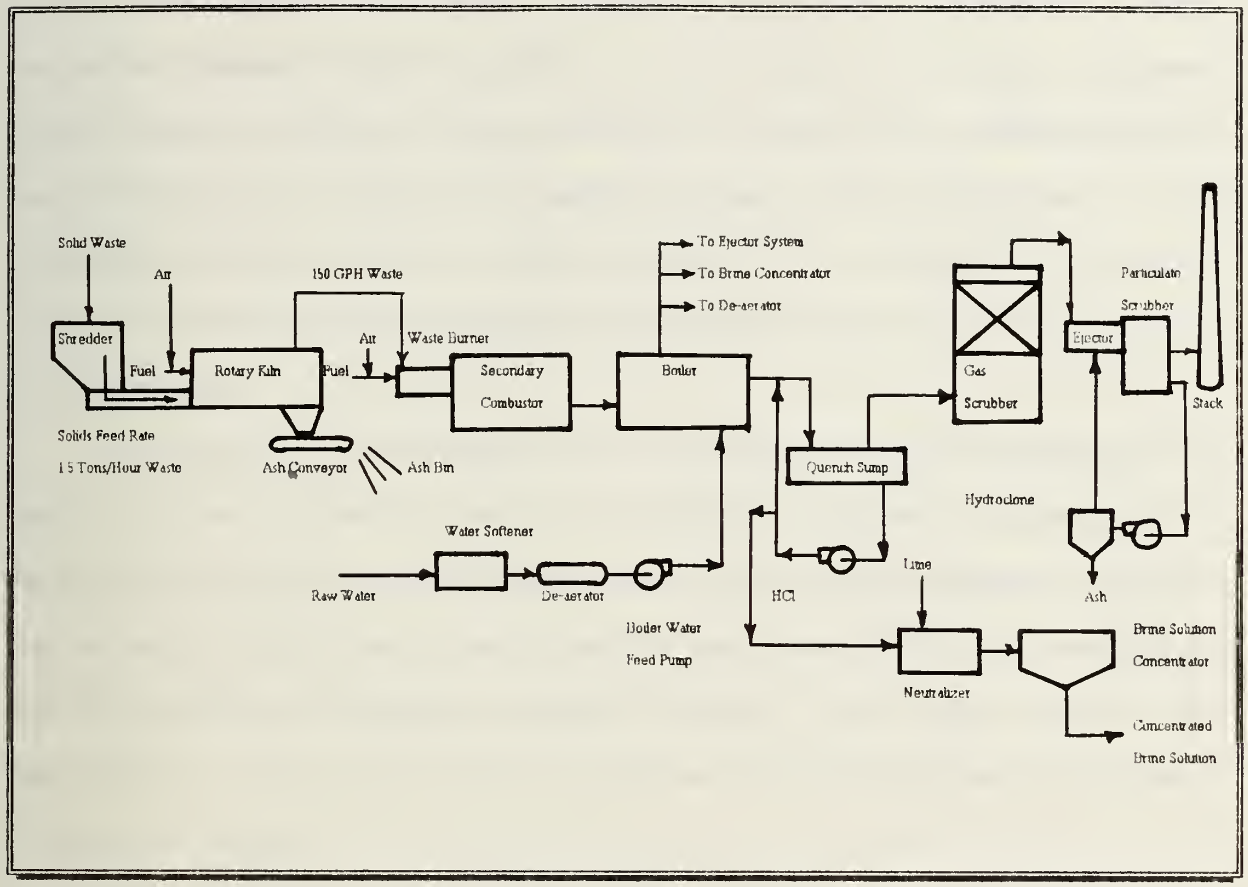
While some incinerators can operate at temperatures that produce all ash in the molten form, a non-slagging incinerator is desirable for soil incineration. The organic constituent of the soil will be combusted, but it is advantageous for the inorganic fraction of the soil to remain in its previous condition to allow its return to the site. The volume of the soil lost during incineration can be replaced with clean fill or compost. Since the soil will be sterilized during the thermal treatment, the use of compost could provide two benefits: 1) organic compounds are provided to speed the return to a natural condition, and 2) a use is found for the product of composting stations.

Key issues for incineration contracts

The CLEAN contract concept appears to be an ideal vehicle for implementation of incineration. It will allow the Navy to work repeatedly with the same contractor and to gain confidence in the incinerator's capabilities. Repeated use of the same incinerator system for similar wastes should reduce the time required for permitting since regulating agencies will have had the opportunity to witness the incinerator in operation on a previous cleanup project.

A cost-plus contract will fit the unknowns of soil incineration well. During the implementation of a cleanup, the exact boundaries of the contamination and the exact quantities of contaminated soil are unknown. The cost-plus contract allows the contractor to continue operation until the site is clean without having to modify the contract for additional incineration quantities or time on site.

Process Flow Diagram: Mobile Rotary Kiln Incinerator System[8]



Source: ENSCO Environmental Services

Figure 5

Even though the contractor will be operating the incineration program, the Navy's responsibilities will continue throughout the operations, especially at a Navy site on the National Priorities List (NPL). Under Section 119 of SARA, a response-action contractor working at a SARA site (Superfund site) will not be held liable under any Federal law for releases of hazardous substances unless they result from the contractor's negligent action or willful misconduct.[21] To avoid liabilities, the Navy must have representatives knowledgeable with the entire program and the current status of the operations.

An initial step in any attempt to utilize incineration must involve getting EPA's support for the remediation plan. The fact that EPA supports incineration as the treatment technology for a particular site will provide a strong argument in response to anti-incineration opposition. In fact, it would be much easier if EPA would mandate the use of incineration, but that seems unlikely at this time. Close contact with state and local agencies will also ensure that their questions are answered before the program is defended to the public.

Some public opposition to incineration should be expected and should be viewed as an additional permitting requirement. If treated with an honest attitude, public groups can be convinced that the advantages of incineration exceed the risks, especially after the Navy has a few incineration contracts behind it.

A contractor will be expected to prove qualifications and past experience. It is important that the Navy contract with a party that has had considerable experience dealing with the EPA. Also, the Navy must ensure that the contractor's equipment is capable of handling the wastes involved. A cost-plus contract is not the time for the contractor to experiment and modify his equipment. The equipment must have a past history of achieving the DRE required by the regulating permit.

Key issues:

Contractor's Continuation of Services

Because of the nature of the remedial work and the hazardous wastes involved, the contract should include provisions that the contractor cannot suspend work without the consent of the Government. This would prevent the contractor from suspending work due to some contractual argument and leaving the site in a condition which may be hazardous or that may increase the extent of the contamination. With a cost-plus contract, this type of contractual dispute is not expected; costs that can be proven are paid. However, because of time constraints and contractor specialization, the Government cannot easily get another contractor to fulfill the contract requirements if the initial contractor stops work for whatever reason. A contract clause requiring the continuation of work may help prevent this scenario.

Independent Air Monitoring Company (AMC)

Because of the importance of the process control and resulting DRE, the Navy would do well to have an air monitoring and testing contractor independent of the incineration contractor. Patterned after the standard Contractor Quality Control (CQC) system for large construction contracts, where the contractor supplies a quality control organization that reports directly to the president of the company and is independent of the field production crew, the contract should require the contractor to hire, as a subcontractor, the air monitoring contractor. The contract should require that the AMC be independent of all other field supervisors and that they report their testing results directly to the Navy, the local regulating agency, and the prime contractor's corporate office. Of course, copies of the report can and should be given to the on-site incineration supervisor.

It is also important that the AMC be given the responsibility of notifying the Navy whenever unsatisfactory test reports are identified. The incineration supervisor will have the responsibility to correct the problem or shut down the incinerator. The fail-safe mechanisms will also be in place to shut down the incinerator automatically if the emission quality deteriorates beyond acceptable limits.

RCRA Inspections

The contract should specifically identify the responsibility of the prime contractor to prepare for and pass all regulatory inspections. If the contractor fails an inspection or incurs costs which would not have been incurred otherwise, the contract should dissociate the Navy from the liability for the reimbursement of these costs. Also, the contractor must be liable for all costs incurred by all parties during any operational shutdown that is due to permit violations.

RCRA Permits

The contract should be written so that it is considered terminated if permits cannot be obtained. Before initiating the contract, the Government will have performed extensive preparatory work to ensure that the use of incineration is acceptable by the regulatory agencies. By the time a contract is awarded, most of the permits still required should pertain to the incinerator. If a permit is ultimately denied for the project because of public or environmental concerns, the contractor should not be held liable for any costs incurred. However, if an operating permit is ultimately denied because of the contractor's actions or inability to meet the required DREs, the Government should not be held accountable for the reimbursement of the contractor's costs. After all, the proper operation of the incinerator is a contractor function and is beyond the control of the Government. However, the nature of the work demands protection of the contractor from the standard Termination for Default clause. In the

standard Termination for Default clause, the contractor is held financially responsible for all costs in excess of the contract amount that are incurred by another contractor while finishing the work. Instead, a clause should be included into the contract which states that if a contractor is not able to permit his incinerator for the specific application at hand, it will either provide another incinerator or withdraw from the contract. Either way, the Government should be absolved from the costs of any failed permit attempt.

An important responsibility of the contractor is the test burn and the incineration permit. Table 7 lists many of the permit-limited parameters for hazardous waste incinerators.

Emergency Response

The contractor must be required to prepare and implement an emergency response plan to protect the workers on-site and the surrounding public. The fail-safe mechanism should provide protection against the continued combustion of the waste if problems occur and thereby eliminate continued emission of PICs. The contractor's plan will include, but not be limited to, the following factors:

1) Notification procedures for police, fire, and ambulance services.
2) Emergency fire and health training for on-site workers.
3) Thorough indoctrination for off-site emergency workers about the site layout and incinerator characteristics.
4) Clearly-marked access roads.

If the remediation project is on a Naval installation, the on-base fire department must be trained in the emergency-response requirements for the incinerator. In remote areas, the contractor may be required to provide on-site firefighting capabilities. It may be advantageous to install fire mains to the site for this purpose. Although in a cost-plus contract the Navy will pay for all of the costs associated with on-site emergency equipment and the installation of utilities, it must be emphasized that the contractor is responsible for the operation of its equipment and for the emergency response to any

problems. The Navy, of course, will allow the use of existing services, but it will not accept contractual responsibility for the safety of the site.

The Navy, on the other hand, is responsible for the operations onboard its installations. The resident Navy representative will have to ensure that the emergency programs are in place and are operating properly and will have the responsibility to notify the contractor about any deviation from the approved permit and emergency response program.

Site Acceptance and Clean-up

The contractor will be required to remove all temporary utilities and structures unless accepted by the Navy. Before demobilization, a comprehensive site analysis needs to be completed to ensure that the site is totally clean. Representatives from EPA and the local regulatory agencies should be given the opportunity to examine the site and review the findings. A successful site clean-up will probably be used by all concerned parties to demonstrate their success toward environmental restoration and the Navy should promote this. Greater cooperation can be expected in the future if these agencies are given a portion of the credit.

Site Reclamation

If at all possible, contaminated sites should be returned to a condition promoting the environment. After a specified period has elapsed to ensure the safety of the site, the sites can be used as parks or recreational areas. A better alternative would be a commitment to return the area to a forest or wildlife area. The Navy could continue its wildlife programs, as well as reap public relation benefits, if it could show that it is returning these contaminated sites back to nature. The location of the site would determine if this action is feasible, but the reward from this policy could be substantial.

Typical Permit-Limited Parameters for Hazardous Waste Incineration[11]

Parameters related to Waste Destruction

- Minimum temperature at each combustion chamber exit
- Maximum feed rate of each waste stream to each combustion chamber
- Maximum CO emissions
- Maximum flue gas flow rate or velocity
- Maximum size of containerized waste to primary chamber

Parameters for Air Pollution Control Devices

- Minimum pressure drop for venturi scrubber
- Minimum water flow rate and pH to absorber
- Minimum water/alkaline reagent flow to dry scrubber
- Minimum particulate scrubber blowdown rates
- Minimum KVA for electrostatic precipitator and KV for ionizing wet scrubber
- Minimum and maximum pressure drop for baghouse filter
- Maximum chloride and ash input in waste feed

Additional Parameters Based on Test Results or Design Limitations

- Maximum pressure in combustion chambers
- Maximum total heat input for each chamber
- Liquid injection burner settings:
  - Viscosity (maximum)
  - Turndown (maximum)
  - Atomization pressure (minimum)
  - Waste heating value (minimum)
  - Solids (suspended solids, particle size)(maximum)
- Incinerability limits for organics

Table 7

Conclusion

Incineration is an acceptable treatment technology for the remediation of contaminated soils. Its advantages and versatile application should make it the first choice in many instances, especially when the destruction of the wastes is desired. The U. S. Navy can take advantage of these characteristics to conduct its environmental restoration program, ensuring rapid site clean-up with waste destruction and thereby eliminating future liability and future clean-up actions.

Incineration has been shown to be an established technology with considerable research and experience supporting the incinerators in use today. With rigid controls and thorough permitting procedures, incineration is a safe technology that can provide the cure to most of the contaminated sites found across this country. Public awareness and confidence is sure to grow as the safe application of incineration is demonstrated more frequently.

The use of incineration in Navy contracts will not require radical changes in contracting methods. However, because of the nature of the site remediation work, special considerations must be given to the incinerator contractors to promote interest in Navy contracts. With so few incinerators in use today, contracts must be written to ensure project completion by the initial contractors. These contractors must be protected as much as possible from the contingencies and unknowns of incineration services.

APPENDIX

List of Acronyms

AMC	Air Monitoring Company
BDAT	Best Demonstrated Available Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liabilities Act
CLEAN	Comprehensive Long Term Environmental Action, Navy
CO	Commanding Officer
CQC	Contractor Quality Control
EFD	Engineering Field Division
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
DRE	Destruction and Removal Efficiency
EPA	Environmental Protection Agency
FS	Feasibility Study
LT^3	Low Temperature Thermal Treatment
MTU	Mobile Treatment Unit
NACIP	Navy Assessment and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
NPL	National Priorities List
PI	Preliminary Investigation
PIC	Product of Incomplete Combustion
POHC	Principle Organic Hazardous Constituent
POL	Petroleum, Oil, and Lubricants
PWO	Public Works Officer
RCRA	Resource Conservation and Recovery Act
RAC	Remedial Action Contract
RAP	Regulating Agency Permit
RI	Remedial Investigation
RA	Remedial Action
RD	Remedial Design
ROD	Record Of Decision
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
TTU	Transportable Treatment Unit
UST	Underground Storage Tank
VOC	Volatile Organic Compound

Bibliography

1. Engineering News Record, "Technologies gain slow nod," March 11, 1991, page 15.

2. Rooney, Patrick, "Incinerating Hazardous Waste Needs A Systems Approach," Proceedings of the 82nd Air and Waste Management Association Annual Meeting, June 25-30, 1989.

3. Lee, C. C. et al., "Review of Mobile Thermal Technologies for Solid Waste Destruction," Proceedings of the 83rd Air and Waste Management Association Annual Meeting, June 24-29, 1990.

4. Hazardous Waste Incineration: A Resource Document, The American Society of Mechanical Engineers, New York, NY, 1988.

5. Wentz, Charles A., Hazardous Waste Management, McGraw-Hill Publishing Company, New York, NY, 1989.

6. Pfeffer, John T., Course Notes for CE 344 Solid Waste Management, Department of Civil Engineering, University of Illinois at Urbana-Champaign.

7. Brunner, Calvin R., "Industrial Waste Incineration," Hazardous Material Control, July/August 1989.

8. Glynn, W. et al., Mobile Waste Processing Systems and Treatment Technologies, Pollution Control Technology Review No. 147, Noyes Data Corporation, 1987.

9. Bonner, T. et al., Hazardous Waste Incineration Engineering, Pollution Control Technology Review No. 88, Noyes Data Corporation, 1981.

10. Sittig, Marshall, Incineration of Industrial Hazardous Wastes and Sludges, Pollution Control Technology Review No. 63, Noyes Data Corporation, 1979.

11. Boomer, Bruce A., and Schliesser, Steven P., "Preparing for RCRA Incinerator Inspections," Proceedings of the 82nd Air and Waste Management Association Annual Meeting, June 25-30, 1989.

12. Ho, Min-Da et al., "Long-Term Field Demonstration of the Linde Oxygen Combustion System Installed on the EPA Mobile Incinerator," Proceedings of the 82nd Air and Waste Management Association Annual Meeting, June 25-30, 1989.

13. deCastro, B. Rey, "A Big Role for Rolling Incinerators," Waste Age, January 1989.

14. Nielson, Roger et al., "Low Temperature Thermal Treatment of Contaminated Soil," Proceedings of the 82nd Air and Waste Management Association Annual Meeting, June 25-30, 1989.

15. Arniella, Elio F., and Blythe, Leslie J., "Solidifying Traps," Chemical Engineering, February 1990.

16. deCastro, B. Rey, "How The Market Is Developing," Waste Age, March 1989.

17. Shea, Timothy J., and Mayhew, Joe J., "A Comparative Assessment of Incinerators Versus Landfills for Hazardous Waste Management," Proceedings of the 38th Purdue Industrial Waste Conference, Purdue Research Foundation, 1984.

18. Pirages, Suellen, "Incineration's Future: Muddy, But Strong," Waste Age, May 1989.

19. Turkeltaub, Robert B., and Wiehl, Christopher D., "Cleaning Up Explosives Contamination at Army Munitions Plants Using Incineration," Hazardous Material Control, July/August 1989.

20. Bolton, D. A., and Hinshaw, G. D., "Permitting Hazardous Waste Incinerators: A California Perspective on the Trial Burn Process," Proceedings of the 82Nd Air and Waste Management Association Annual Meeting, June 25-30, 1989.

21. Olah, Nicholas J., Remedial Measures Initiation Decision Report, Volume I, Naval Facilities Engineering Command, October 1988.

22. Handley, Mark A., "WESTDIV's Approach to Installation Restoration Contracting," The Military Engineer, The American Society of Military Engineers, August 1989.

23. Zagrobelny, Ted, "The Installation Restoration Program: Facing the Environmental Challenges of the 1990s," Navy Civil Engineer, Winter, 1991, Naval Facilities Engineering Command, Alexandria, VA.

24. Civil Engineer Corps Biweekly Newsletter, Naval Facilities Engineering Command, September 21, 1989.

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